AGE DETERMINATION OF *NOTOTHENIA ROSSII* FROM SOUTH GEORGIA (ANTARCTICA) USING SCALES AND OTOLITHS

by

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ABSTRACT. – Age determination of *Notothenia rossii* sampled nearshore was carried out using scales and otoliths. Otolith development during the life-cycle is described. Otoliths were either examined whole or embedded in polyester resin, thin sectioned and examined under the microscope. Analysis of otolith and scale structures of blue phase fingerlings and young offshore specimens showed no evidence of pelagic fingerlings overwintering at sea before migrating to coastal habitats nearshore. Within a few weeks of arrival nearshore, the fish changed to a demersal brown phase fingerling at the stage when 9 - 11 circuli were present on the scales. The nearshore population of *N. rossii* consisted mainly of age classes 0 - V with a total length range of 41 - 450 mm. There was considerable change in the external shape and morphological structure of otoliths with increasing age of *N. rossii* during the first five years, however once maturity was reached further otolith changes were minimal although the structure continued to grow in size.

RESUME. – La détermination de l'âge de *Notothenia rossii* (spécimens côtiers) a été faite par scalimétrie et otolithométrie. L'auteur décrit le développement des otolithes pendant le cycle biologique. Les otolithes ont été observés entiers ou bien, après montage dans une résine polyester, de fines sections ont été examinées au microscope. L'analyse des structures des otolithes et écailles des alevins et des juvéniles n'a pas permis de démontrer l'existence d'une phase hivernale en haute mer avant la migration vers les zones côtières. Quelques semaines après leur arrivée en zone côtière, les poissons se modifient, deviennent démersaux et prennent une couleur brune : il y a alors 9 à 11 circuli sur les écailles. La population côtière de *N. rossii* comprend surtout des individus appartenant aux classes 0 à V avec des tailles comprises entre 41 et 450 mm. Au cours des 5 premières années, il y a une modification profonde de l'allure et de la structure morphologique des otolithes en fonction de la croissance. Cependant, après la maturité sexuelle, les modifications des otolithes sont minimes, bien que leur taille continue de s'accroître.

Key-words : PSW South Georgia, Notothenia rossii, Pisces, Scale reading, Otolith reading, Age determination.

Age determination of Antarctic fish is now well established due largely to the reports of the BIOMASS workshops on the ageing of Antarctic fishes (Everson, 1981; DeWitt, 1982). Age determination using the technique of charring otoliths is widely practiced, but this method is both destructive and time consuming. Therefore a new method of otolith examination developed by Bedford (1983) was used.

There is much uncertainty on the age determination of *Notothenia rossii* from age classes 0 - V. The identification of the first annulus needs to be based

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on adequate knowledge of the young stages of the species. Until now, published literature on larvae and young fingerling stages has been limited.

It is sometimes possible to identify a fish species by its otolith structures even though several species may possess similar external morphological characteristics (Yukhov, 1971). This is particularly useful for identifying species of fish, and estimating their size, from otoliths collected in the stomach contents of predators.

The age determination of *N. rossii* at South Georgia has previously been studied by Olsen (1954). Kozlov and Pinskaya (1971), Shust and Silyanova (1971), Crisp and Carrick (1975) and Freytag (1980).

This paper reports on the determination of ageing techniques and the age interpretation of *N. rossii* using scales and otoliths. The investigation concentrated upon young nearshore stages of *N. rossii*. The investigation was carried out from Grytviken, South Georgia (54°17'S-36°30'W) from January 1978 to January 1980.

MATERIALS AND METHODS

Samples of *N. rossii* were collected from Cumberland East Bay. South Georgia. The sampling techniques used to obtain the size range and condition of fish have been described by Burchett (1983).

Each month during the sampling period, 80 - 100 juvenile specimens of *N. rossii* over a wide size range were sampled nearshore. The sagittal otoliths and approximately 10 scales were removed from each specimen. The method used for the preparation and examination of the scales have been described by North *et al.*, (1980).

Otoliths were processed using the technique developed by Bedford (1983). The otoliths were orientated with the nuclei aligned in rows of specially prepared moulds and embedded in black polyester resin. Up to 120 otoliths of juvenile *N. rossii* were embedded in a single mould, normally 12 to a line. The positioning of the otoliths, alignment of their nuclei and cutting was crucial in order to display all the annuli. Alignment of otolith nuclei was accomplished with the aid of an aligment board (Figure 1). When viewed from above, the three guide wires merge and the otolith nuclei were placed directly underneath. Thin sections were then cut throught the nuclei of the rows of otoliths using a high speed diamond saw. This technique has been successfully used on otoliths of the Antarctic fish, *Dissostichus mawsoni* (Burchett *et al.*, 1984).

The otolith thin sections were mounted and fixed on standard microscope slides using clear polyester resin. These sections were examined under a binocular microscope. Both transmitted and reflected light were used to assist with the identification of the annular rings.

Whole otoliths were examined directly under a binocular microscope using reflected light. The shape of the otoliths of mature fish is characteristic with slight deviations for specimens of both sexes (Yukhov, 1971). However, considering this variation and the fact that specific features are most clearly manifested with age, it was possible to describe the development of the otolith. Terminology used for the description of the otolith structure is the same as that used by Yukhov (1971).

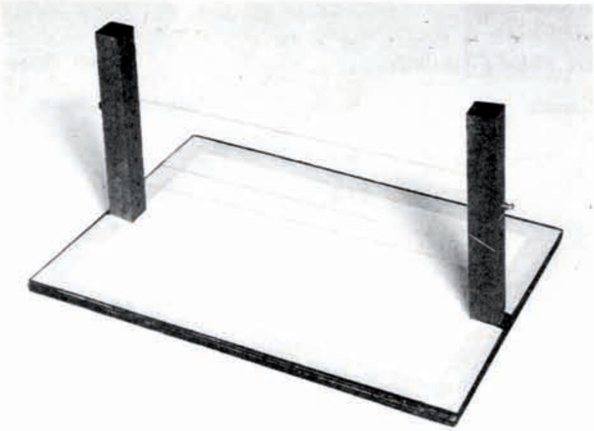


Fig. 1. - Otolithalignment board (300 mm x 200 mm).

RESULTS

Scales of fingerlings

Examination of two young fingerlings, one 25 mm and the other 26 mm in length (sampled in March 1979) showed that under the microscope, rudimentary scale development was taking place over some parts of the body. Specimens caught offshore at 35 mm long were well scaled all over the body and the scales consisted of well formed centra but no circuli. On specimens 38.5 mm in length (sampled in February 1978), scales were 0.6 mm in diameter with 0 - 1 circulus discernable. When the blue phase fingerlings arrived nearshore in March, the scales had 7 - 11 circuli (Figure 2 and Table I) and a modal value of 9. Brown phase fingerlings caught in June 1979 had 12 - 19 circuli and a modal value of 15- 16 (Table I).

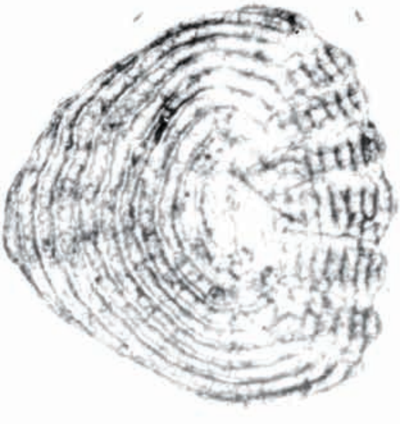


Fig. 2. – Scale (0.8 mm in diameter) of a blue phase fingerling of *Notothenia rossii* 61 mm in length which was sampled nearshore at South Georgia in March 1979.

Table I. – Numbers of circuli on the scales of 124 blue phase and 30 brown phase fingerlings of *Notothenia rossii*.

Blue Phase Fingerlings			Brown Phase Fingerlings		
Number of circuli	n	%	Number of circuli	n	%
7	12	9.7	12	1	3.3
8	32	25.8	13	5	16.7
9	40	32.3	14	5	16.7
10	36	29.0	15	6	20.0
11	4	3.2	16	6	20.0
			17	4	13.3
			18	2	6.7
			19	1	3.3

Examination of the scales of the blue phase (pelagic) fingerlings arriving nearshore in late March showed that 88 % had the initial indication of a first annual check. The changes in morphology and behaviour from blue phase, pelagic fingerling to demersal brown phase fingerling occurred when the scales had 9 - 11 circuli descernable.

Otoliths of young *Notothenia rossii*

Whole otoliths examined from 110 blue phase fingerlings sampled in March 1979 (Figures 3 A and B) all had central opaque nuclei and no evidence of a hyaline zone that would indicate a period of winter development.

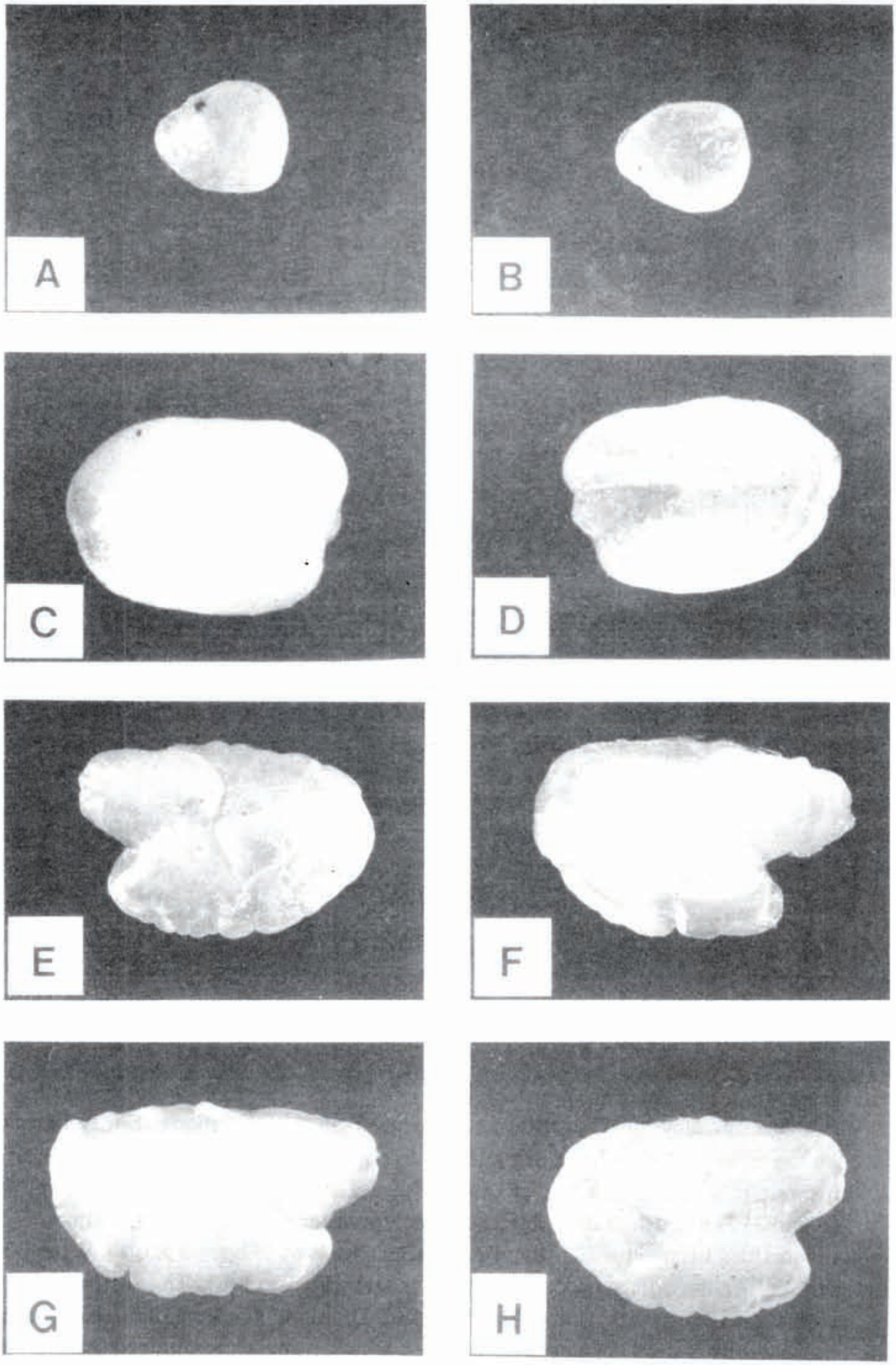
Further examination of otoliths from fingerlings arriving nearshore during the January and February of 1978, 1979 and 1980 also showed no complete annulus formation.

Otoliths of 2579 juvenile specimens of *N. rossii* caught during 1978 and 1979 were sectioned and age determined. Transverse sections of otoliths of selected age classes are shown in Figure 4 and the frequency of length at age obtained from the otolith age interpretation in presented in Figure 5.

Description of otolith development

Several distinct morphological changes occurred in the development of the otolith structure during the early life-history of *N. rossii* from fingerling (age classe 0) to mature adult (age class VI +) and this is shown in Figure 3. However, once fish maturity has been reached, otolith shape remained relatively constant, but

Fig. 3. – Whole otoliths showing inner (on the left) and outer (on the right) surfaces of selected age classes of *Notothenia rossii* sampled at South Georgia during 1978 and 1979. Length x height (mm) of otoliths : age class 0 (Fig. A and B).. 0.44 x 0.38; age class I (Fig. C and D).. 0.91 x 0.66; age class II (Fig. E and F).. 3.16 x 1.97; age class III (Fig. G and H).. 3.50 x 2.01; age class IV (Fig. I and J).. 4.03 x 2.44; age class V (Fig. K and L).. 4.13 x 2.43; and age class IX (Fig. M and N) .. 6.17 x 4.03.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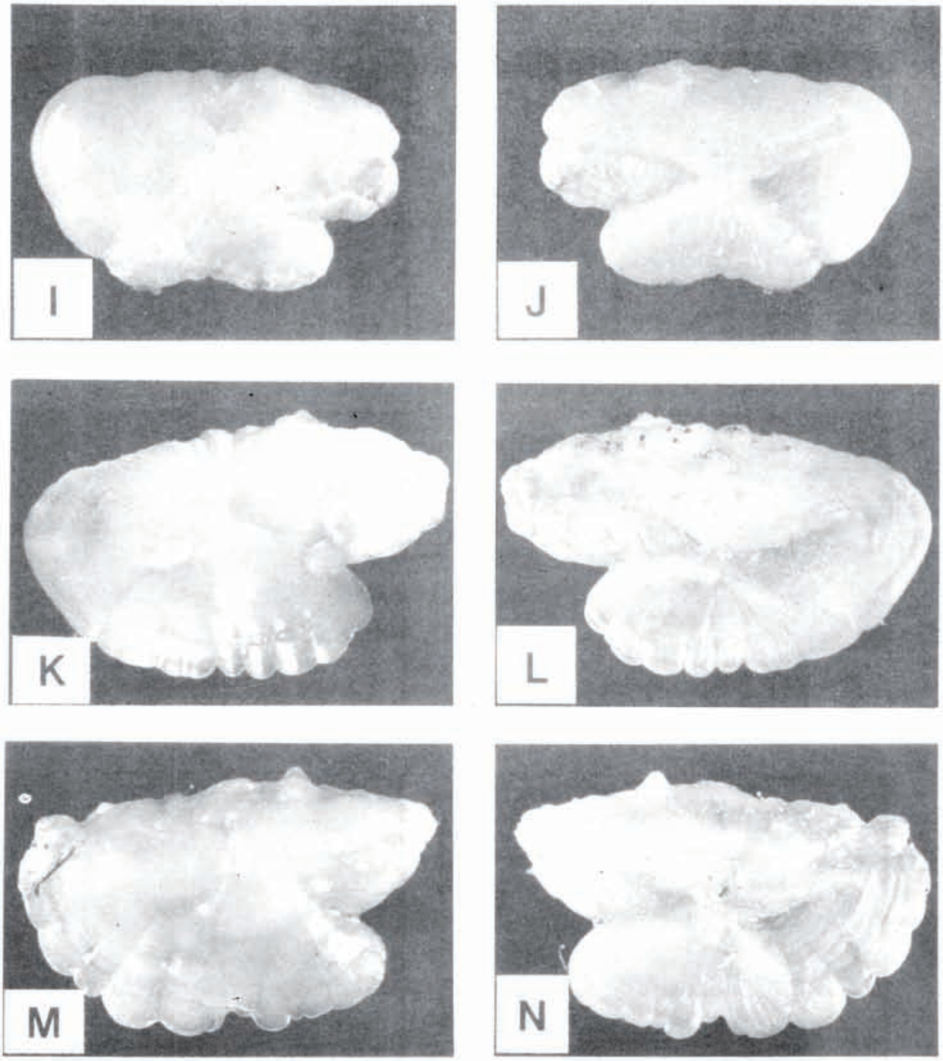

Fig. 3 (continued).

there was a continuation of growth in size.

Otoliths of young fingerlings begin as oval granules which are slightly flattened on the inner surface (Figure 3 A and B). As the fish becomes older there is a relative increase in length and width of the otolith which becomes more plate-like in shape (Figure 3 E and F). During development, the outer surface of the otolith develops tuberosities between which there are distinct furrows (Figure 3 K), while the inner surface becomes flattened or slightly concave (Figure 3 L). The rostrum also increases in length with age (Figure 3 I and J). Along the longitudinal axis of the otolith runs a deep channel (the sulcus), which is most pronounced on the inner surface. This starts to develop in fish of age class I (Figure 3 C and D) and by age class III (Figure 3 G and H), two V-shaped grooves converge at the collum, that in turn divides the anterior and posterior portions of the otolith. During development of the otolith, the dorsal margin and later, to a lesser extent, the ventral margin develops numerous convex projections which are especially pronounced in the older fish (Figure 3 M and N).

DISCUSSIONS AND CONCLUSIONS

There has been much uncertainty on the question of age and the interpretation of ageing in *N. rossii* of age classes 0 - V.

Freytag (1980) examined scales to estimate the age of *N. rossii* mostly using specimens caught offshore from around South Georgia and South Shetland Islands. Shcherbich (1975) also used scales for his age determination of *N. rossii* and included some fingerlings among the material examined. However, controversy arises as to how long the fingerlings remain at sea. It has been suggested that offshore fingerlings comprise two groups from different spawning seasons (Shcherbich, 1975). Therefore there would be overwintering fingerlings at sea of both age classes 0 and I if the agreed birthday of fish in the Southern Ocean was taken as 1st July (Shcherbich, 1975).

Examination of the scales of blue phase fingerlings of *N. rossii* arriving nearshore in late March showed that 88 % had the initial indications of a first annual check at the outer margin. Examination of the equivalent otolith structure (Figure 3 A and B) showed only opaque nuclei and no evidence of the start of the hyaline zone (winter growth band). On the basis of this observation together with the fact that fingerlings arrive nearshore with no complete annulus formation, there is no evidence to support the suggestion that some fingerlings may spend the first year epipelagically at sea before moving nearshore.

Using thin sectioned otoliths from specimens sampled by trammel nets (Figure 4) and examination of whole otoliths and scales from nearshore fingerlings (Figures 2 A, B and 3) it was demonstrated that the nearshore population of *N. rossii* consisted predominantly of fish between age classes 0 and V (Figure 5).

The shape and morphology of the otolith changes considerably during the early development of *N. rossii*. However, based on the description of otolith development and the key presented in Figure 3, the fish species should now be identifiable during all ages from its whole otolith structure. This will be useful for future fish identification based upon otoliths such as those removed from stomach samples of predators.

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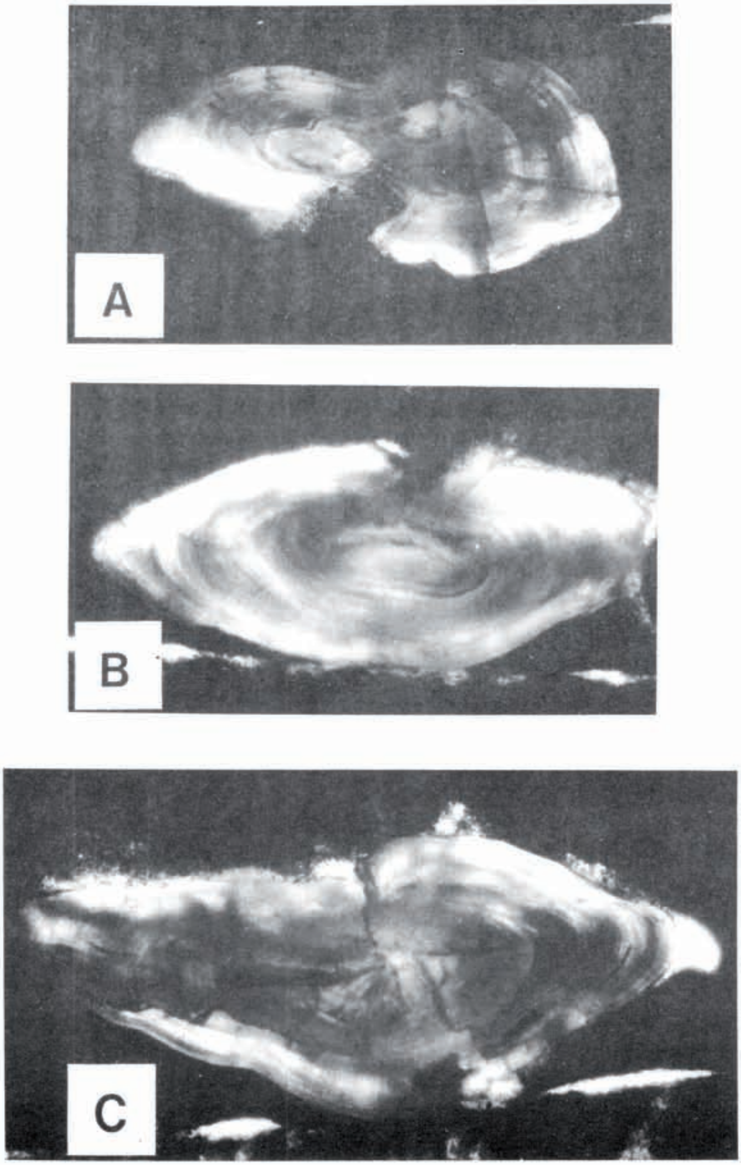
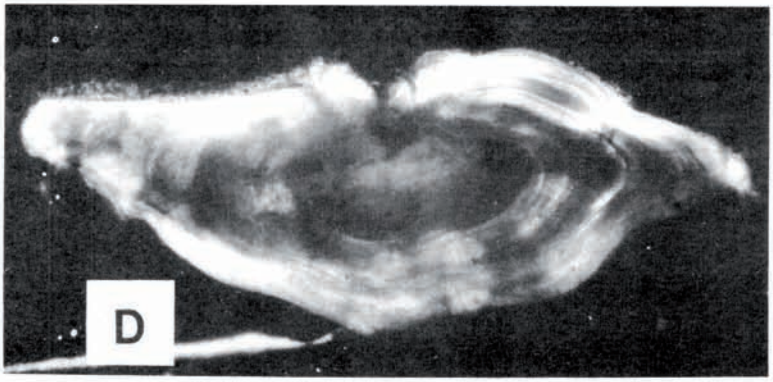


Fig. 4. – Transverse sections of otoliths of selected age classes of *Notothenia rossii* sampled at South Georgia during 1978 and 1979. Height x width (mm) of sectioned otoliths : age class III (Fig. A).. 1.75 x 0.69; age class IV (Fig. B).. 1.94 x 0.84; age class V (Fig. C).. 2.19 x 0.97; age class VI (Fig. D).. 2.72 x 1.16.



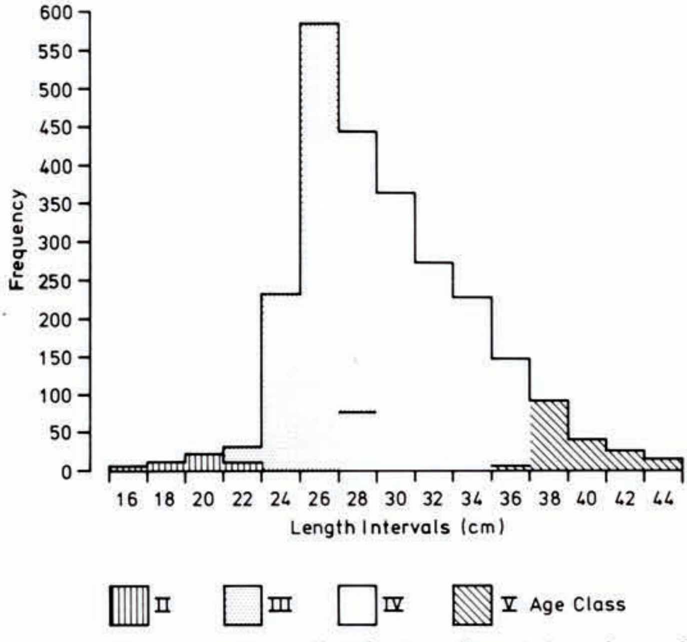


Fig. 5. – Frequency of length at age for *Notothenia rossii* sampled nearshore at South Georgia during 1978 and 1979.

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